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Tackling Lack of Motivation in Aspirational Analytics Companies:
SME Examples from the Manufacturing Industry

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ABSTRACT

Establishing business intelligence analytics (BIA) in small- and medium-sized manufacturing enterprises is a pervasive problem. SME's - the majority of businesses - play an important role in creating jobs, but research is primarily focused on large corporations. The authors worked with small manufacturing companies at the aspirational capability level but found that their motivation to introduce BIA was low. They had many business challenges but perceived the obstacles (primarily cost and effort) as too great, and their priorities were with operational issues. A two-phase approach based on a well-known analytics maturity model was devised to help raise company motivation. The article describes three studies in different companies using variations of the approach. Comparative analysis of the cases shows that demonstrating a clear path to improved functional efficiency is key to improving motivation, and that simple, easy to learn tools can provide these insights at little cost.

KEYWORDS

Business Intelligence, Information systems, Manufacturing, Maturity model, SME

INTRODUCTION

Regardless of size or business domain, companies rely on relevant information to monitor their business activities and to support decision making (Papachristdoulou, Koutsaki, & Kirkos, 2017). Business Intelligence (BI) is used as an umbrella term to cover various technological tools and organizational activities that help decision makers make data-driven decisions and turn business insight into actions (Kumar, Chauhan, & Sehgal, 2012; Lavalle, Hopkins, Lesser, Shockley, & Kruschwitz, 2010; Trieu, 2016). Wixom and Watson (2010) define BI as "a broad category of technologies, applications, and processes for gathering, storing, accessing, and analysing data to help its user make better decisions" (p. 4). BI became established in the 1990's, and a more recent focus on its key analytical component has become known as Business Analytics (BA), which also encompasses big data and big data analytics. This may be understood as a subfield of BI (Davenport & Harris, 2007) or an advanced discipline in itself (Laursen & Thorlund, 2010). We use the term Business Intelligence and Analytics (BI&A) suggested by Chen, Chiang, & Storey (2012) to indicate our focus on technologies, applications, processes and analytics. Research has addressed different aspects of BI&A, including Cloud BI, mobile

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BI and various BI applications (Llave, 2017), and reported transformational success stories. However most of these successes involve large companies: Continental Airlines (Anderson-lehman, Watson, & Wixom, 2008), Netflix (Valacich & Schneider, 2010) or Target (Sharda, Delen, & Turban, 2014). When it comes to small- and medium sized enterprises (SME's) the published work is limited, even though SME's constitute the backbone of national economies (99% of all European companies are categorized as small or medium sized (Airaksinen, Luomaranta, Alajääskö, & Roodhuijzen, 2015). This research gap has been addressed in literature (Grabova, Darmont, Chauchat, & Zolotaryova, 2010; Llave, 2017; Scholz, Schieder, Kurze, Gluchowski, & Böhringer, 2010), but not substantially addressed even though it has been pointed out that both researchers and practitioners need better understanding on how organizations get value from BI&A (Trieu, 2016). In a comprehensive literature review of BI&A and analytics in SME's from 2000 to 2016, Llave (2017) showed that popular topics included data warehousing, dashboards, data mining, cloud services and BI&A implementation. However, the relevant research was sparse: nine articles in 2000 focused on BI adoption and three on BI&A benefits for SME's (Llave, 2017), only three from 2015 and seven from 2016 covered any BI&A topic. Recent interest in big data has refocused research attention on intelligence and analytics, but SME's are still neglected.

In our empirical work with SME's, we also find that the level of interest for BI&A is limited. SME's have previously been shown to be ignorant of the potential of BI&A (Baransel & Baransel, 2012; Gudfinnsson, Strand, & Berndtsson, 2015; Voicu, Zirra, & Ciocirlan, 2010), or to be late adopters. Though SME's obviously differ in their BI awareness, Olszak and Ziemba (2012) showed that lack of managerial support, and ignorance of how BI&A could contribute to business success were amongst the most prevalent organizational barriers for SME's. In a research project concerned with implementing BI&A in small and medium sized manufacturing companies[1] (for the remainder of this paper we will call small and medium sized manufacturing companies SMME's) the authors also found that managerial interest, and company awareness of BI&A's potential could not be taken for granted – motivation for adopting analytics was low. The companies involved were often content with their current IT support and saw no reason to use limited resources on expensive IT or complex analytics. It seems that BI&A researchers show enthusiasm for data analysis tools and techniques, but have little secure knowledge of BI&A in SME's, whereas SME practitioners, even in advanced technological societies like Sweden, show limited awareness of BI&A potential, and low motivation for adoption. Engaged researchers working with companies in the field therefore need to address the issue of improving company-wide motivation for BI&A. This can be understood as an essential prerequisite for BI&A adoption and especially important for SMME's as they face the challenges of smart factories and industry 4.0 (Shrouf, Ordieres, & Miragliotta, 2014). The research objective of this article is therefore to devise and evaluate ways of improving BI&A motivation in SMME's. This research forms part of a larger project that focuses on helping SME manufacturing companies to work with continuous improvement.

In this article, we examine the available literature and derive a theory-based intervention approach for improving motivation from the maturity model of Lavalle et al. (2010). We explain the action case research method and describe three variations of the approach in different SMME's. We provide an evaluation of the different intervention experiences and discuss avenues for future research in the area.

SME'S: BUSINESS INTELLIGENCE AND ANALYTICS ADOPTION

There are a variety of approaches to supporting companies in adopting BI&A usage; here we discuss three: maturity models, critical success factors and BI&A readiness. BI&A improvement projects continue to be high-risk despite these research efforts, with many ending in failure (Hawking & Sellitto, 2010; Olszak & Ziemba, 2012).

Maturity models are used to analyse companies' developmental stage in relation to BI&A, defining expectations (Popovič, Hackney, Coelho, & Jaklič, 2012) and to highlight weaknesses (Rajterič,

2010). Maturity models have been a popular approach both in academic research (Enterprise Business Intelligence Maturity (Tan, Sim, & Yeoh, 2012), Ladder of Business Intelligence (Cates, Gill, & Zeituny, 2005), and in industry (Business Intelligence Development Model (Spruit, Marco, Sacu, 2010)). Hewlett Packard, SAS and TERADATA have developed their own maturity models (Thamir & Theodoulidis, 2013). Maturity models indicate a range of BI&A parameters that companies need to address, combined with stages (levels) of maturity in those parameters. Maturity models have been criticized for limited coverage of BI&A aspects, and poor documentation and empirical validation (Chuah & Wong, 2011; Lahrmann, Marx, Winter, & Wortmann, 2011; Rajterič, 2010). They also provide little practical advice for companies wishing to advance to the next level of maturity. They are normally not targeted at SME's and seldom address the issue of early stage motivation. A recent and well-cited maturity model which, though targeted at corporations, does explicitly address the issue of motivation, and has the benefit of both academic and industry backing, is Lavalle et al. (2010) (Table 1).

The model defines three stages of adoption: aspirational, experienced and transformed. The SMME's that we work with are at the aspirational, or in some cases pre-aspirational (not even convinced that they need or want analytics or intelligence) stage. In addition to examining motivation, the model also specifies functional proficiency, business challenges, key obstacles, data management and analytics for decision making as company parameters for development – where our SMME's display recognizable aspirational symptoms. However, the challenge for this research is not to move the companies through the maturity stages, but improve their motivation to the point where they understand themselves as aspirational – in a situation where they need and want to develop their intelligence and analytics capabilities. Lavalle et al. (2010) provide a technique for operationalizing analytics called PADIE. They suggest 1) documenting processes and their applications, 2) using analytics techniques to gain insights and 3) selecting the appropriate approaches to implement the insights in operations (Lavalle et al., 2010).

In some respects, maturity model parameters resemble critical success factors (CSFs) – "the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization" (Rockart, 1979, p. 85). CSFs in Enterprise Resource Planning (ERP) systems have received much attention but work on CSFs for implementing BI&A is limited (Hawking and Sellitto, 2010). ERP systems capture company information which BI&A tools analyse to provide insight for decision-making. Hawking & Sellitto (2010) proposed CSFs from solution, application and temporal perspectives. The most frequent factors are management support, user participation and team skills. Yeoh and Koronios (2010) interviewed 15 experts, and presented seven CSFs in three dimensions; organization, process and technology. Management and championship related factors were top ranked within the organizational dimension. Team-related factors were highly rated in the process dimension (Yeoh & Koronios, 2010). These results support the findings of Hawking and Sellitto (2010). Olszak and Ziemba (2012) identify CSFs in Polish SME's. They expand the organizational, process and technology perspectives, including the following factors:

- Organizational: support from senior management, skilled (qualified) sufficient staff/team/managers and competent BI&A project manager (leadership),
- Process: effective change management, well defined business problem and processes and well-defined users´ expectations, and
- Technology: data quality, integration between BI and other systems, user friendly system.

In general, the most frequently named CSF in literature is management support (Eder & Koch, 2018) although it sometimes can be unclear what this actually means. Eder & Koch (2018) provide an extensive overview of CSFs for BI& based on interviews with 13 experts. Their results support previous findings but also identify additional CSFs:

Table 1. Three stages of analytics adoption, Lavalle (2010)

Categories	Aspirational	Experienced	Transformed
Motive	Use analytics to justify actions	Use analytics to guide actions	Use analytics to prescribe actions
Functional proficiency	Financial management and budgeting Operations and production Sales and marketing	All Aspirational functions Strategy/business development Customer service Product research/development	All Aspirational and Experienced functions Risk management Customer experience Workforce planning/allocation General management Brand and market management
Business challenges	Competitive differentiation through innovation Cost efficiency (primary) Revenue growth (secondary)	Competitive differentiation through innovation Revenue growth (primary) Cost efficiency (secondary)	Competitive differentiation through innovation Revenue growth (primary) Profitability acquiring/ retaining customers (targeted focus)
Key obstacles	Lack of understanding how to leverage analytics for business value Executive sponsorship Culture does not encourage sharing information	Lack of understanding how to leverage analytics for business value Skills within line of business Ownership of data is unclear or governance is ineffective	Lack of understanding how to leverage analytics for business value Management bandwidth due to competing priorities Accessibility of the data
Data management	Limited ability to capture, aggregate, analyse or share information and insights	Moderate ability to capture, aggregate and analyse data Limited ability to share information and insights	Strong ability to capture, aggregate and analyse data Effective at sharing information and insights
Analytics in action	Rarely use rigorous approaches to make decisions Limited use of insights to guide future strategies or guide day-to-day operations	Some use of rigorous approaches to make decisions Growing use of insights to guide future strategies, but still limited use of insights to guide day-to-day operations	Most use rigorous approaches to make decisions Almost all use insights to guide future strategies, and most use insights to guide day-to-day operations

- defining terms, standards and KPIs
- including stakeholders outside the IT sphere, and
- having a comprehensive understanding of business processes.

These studies correlate well with our experiences working with SMME's and support our focus on finding ways to increase BI&A motivation, since the majority of CSFs are organizational rather than technical. The CSF approach can be criticized as too generic (many of the factors are common to most adoption and implementation tasks), but adds some dimensions to those proposed by Lavalle (2010), including an explicit focus on process and teamwork, and some technology implementation concerns.

BI&A readiness defines the prerequisites for BI&A success. A readiness assessment helps companies to understand how prepared they are to make the changes needed to take advantage of BI&A (Williams & Williams, 2007). Anjarini & Zeki (2014) present a conceptual model of readiness factors summarized in seven dimensions:

- Management (support, resources, champion)

- Business (vision, business case and measurable benefits)
- Infrastructure (technical framework, functionality, usability)
- Users (participation, education, commitment)
- Project (planning and scope, delivery approach)
- Teamwork (e.g. skills, consultants, expertise)
- Data (e.g. source systems, quality, metadata) (Anjariny & Zeki, 2014)

In addition to expanding some of the focus areas considered by maturity models and CSF approaches, the readiness assessment adds a project-based view. However, the companies in our study often needed to improve their motivation before they would consider a BI&A project.

RESEARCH APPROACH

The chosen research method is action case (Vidgen & Braa, 1997). It suits small-scale qualitative investigations of change, with an element of both intervention and interpretation. It recognizes that case study research, though conventionally neutral and objective, often involves researchers in conversations with research subjects that influence events. Researchers may also have the intention to help companies improve practice, without being in a situation to conduct full-scale action research (for instance a full cycle of canonical action research (Davison, Martinsons, & Kock, 2004) due to (for instance) resource limitations or lack of authorization at the host organization. Action case therefore represents a compromise research form. An emphasis on understanding (typical of qualitative or interpretive case studies), is combined with a limited intervention (more typical of action research). There is a balance between focus on change and focus on understanding (see Figure 1).

Action case research is characterized by:

- Small scale interventions with a shorter time frame
- Focused intervention with pre and post studies
- A concern with purposeful change, with a focus on the history and context of the setting
- In depth analysis in the tradition of interpretive case studies
- A focused research question and framework of ideas to be tested
- Limited participation by members of the organization involved, and low planned impact.

We used the enterprise modelling elicitation approach presented by Sandkuhl et al. (2014) as a tool to gather stakeholder views and to identify potential areas that could be supported by BI&A. Both the action case method and the elicitation approach suggest starting with interviews as a preparation before going to the next level of analysing and problem identification. In addition, the elicitation approach also recommends workshop modelling sessions (Sandkuhl, Stirna, Persson, & Wißotzki, 2014).

Research Model

Figure 2 gives the research model for improving BI&A motivation in SMME's, which is developed from Lavalle (2010) and used to guide the action case intervention.

The model describes a two-phase process, where the first phase involves information gathering about company motivation, related to the challenges that the main protagonists perceive in its immediate future, and obstacles to achieving those challenges. Challenges in SMME's are expected to revolve around cost efficiency. Obstacles are expected to include lack of executive (owner/manager) sponsorship, and lack of understanding of the potential of BI&A. Phase 1 is used to target workshop activity in the second phase. Phase 2 workshops aim at improving functional proficiency (for SMME's primarily in the area of operations, production and sales) through examining data management (the

Figure 1. Action case research (R. Vidgen & Braa, 1997)

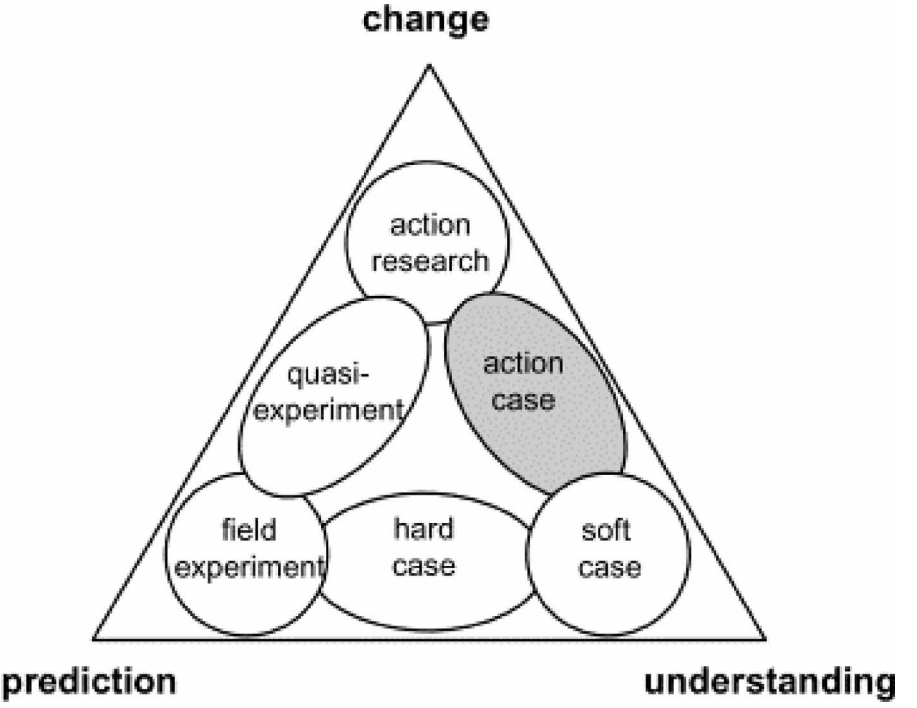
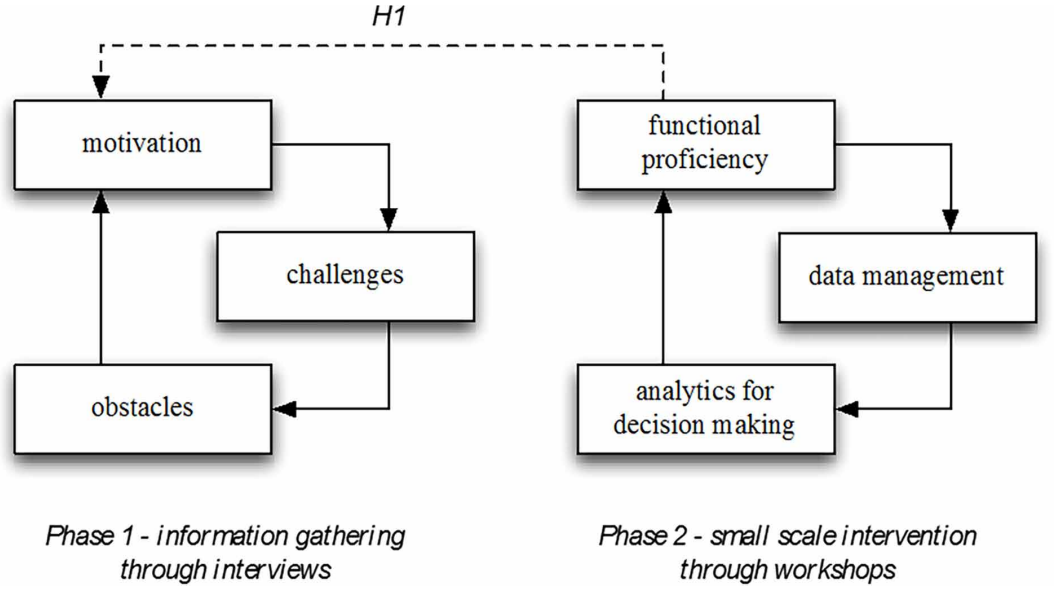


Figure 2. Research model for action case intervention



'ability to aggregate, analyse and share information and insights') and employing those insights to guide decisions about 'future strategies or day-to-day operations' (Lavalle, 2010). Issues concerning process, applications, management support, teamwork and user-participation are addressed through

Table 2. Overview of participating companies

Company name	Num. Employees	Business	Interviews
Company A	50	Screening equipment	9
Company B	120	In-car accessories	19
Company C	250	Furniture	22

the workshop approach. The hypothesis (H1) captured in the model is that understanding challenges and obstacles and focusing workshop activity on operations, data, and decisions to develop clear routes to practical improvements (functional proficiency) will improve the motivation to adopt business intelligence analytics. Since there are many strategies for information collection and many analysis techniques available, the model needs to be instantiated (particular tools and techniques specified for the different activities) before use, and this is described in a later section.

Choice of Action Cases

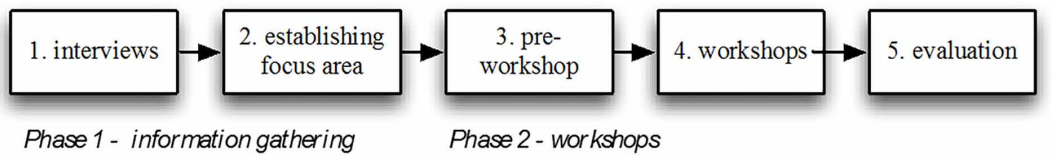
According to the European Commission, small and medium sized companies have up to 250 employees. Three manufacturing SME's were selected to representing different sized companies. Company A is owned by a large international enterprise group and manufactures customized heavy-duty screening equipment for industries worldwide - it has about 50 employees. Company B is a family-owned company that manufactures in-car accessories for mobile devices that are sold both in Europe and in the US. The company has about 120 employees. Company C produces bookshelves and is a subcontractor to a large Swedish furniture company. The company is family owned and has about 250 employees. All three companies are located in Sweden, but operate internationally. Table 2 provides an overview of the companies:

Instantiation of Research Model

Since the research model in Figure 2 only gives the broad shape for an intervention, the detailed research design is given below. This involves five steps (Figure 3) inspired by the phases presented by Vidgen and Braa (1997) and the enterprise model elicitation approach offered by Sandkuhl et al. (2014).

Phase 1 (information gathering), involved 2 steps. In the first step, the research focused on studying the companies. Semi-structured interviews were conducted in each company in order to get an understanding of current IT and BI&A support in the organizations, and to identify obstacles and challenges for increasing BI&A usage. There were 9 interviews in company A, 19 in company B and 22 in company C; 50 interviews in total. The interview questions were based on the categories of the Lavalle et al. (2010) maturity model. We gathered empirical material in all categories, including identifying business challenges already supported by IT. Interviews were transcribed and analysed in NVivo 11 using the techniques of content analysis (Krippendorff, 2004). Coding was based on categories from the maturity model. The challenges code was then used for a more overarching analysis of companywide challenges understood as priorities. A generalized account of these challenges is previously published (Gudfinnsson & Strand, 2017). The detailed challenge analysis served as a

Figure 3. Detailed research design



basis for discussing focus areas. For step 2, the researchers met with management representatives from each company to present an overview of the findings from the interviews. An initial focus area was chosen based on individual company need - an important step forward. Participants agreed how the workshops should be organized and the securing of management involvement. The researchers presented an overview of BI critical success factors where the importance of management support and user participation were emphasized. All three companies agreed to use the elicitation approach. The management representatives presented the chosen focus area and recommended the elicitation approach to their management boards for approval.

Phase two (workshops) initiated with the researchers and the management representatives engaging in a pre-workshop (step 3), where the elicitation process was tested and the approach explained. Following the recommendations of Sandkuhl et al. (2014) a plastic wall was set up in two of the pre-workshops (a whiteboard was used in one). Coloured sticky labels representing different work components were used for simple modelling. In practice the focus area was often elaborated at this step. The pre-workshop provided both the workshop facilitator and the managers a deeper understanding of the chosen problems - important inputs for managers (the elicitation process) and facilitator (work problem understanding). The managers provided a list of stakeholders for the main workshop, and the purpose of the workshop was explained to them prior to the workshop invitation. For phase 2, the focus was on establishing a clear path to functional proficiency through improvements to production and operations processes, with an emphasis on efficiency. The analysis tools were kept very simple to reduce the learning curve, and the sticky label approach was adapted to the different analyses. All the workshops focused to some extent on a key function or process, data requirements for managing it and decision-making for improving it, but with different emphases. Company A focused on the production order function, and used a simple form of process modelling to describe it. Company B focused on production planning and inventory control with an emphasis on data management. A simplified form of information requirements analysis was appropriate for this task. Company C focused on decision-making using the sticky labels for basic decision analysis; they eventually focused on improving communications around production stoppages. The workshops took place in a large meeting room with a projector and plastic wall or whiteboard. Two researchers were present at all workshops; one took the role of facilitator, the other took field notes. A manager from the company introduced the researchers and emphasized the project's importance - a workshop aimed at finding solutions to real problems. After the initial presentations, both researchers introduced themselves and explained their role and the workshop analysis approach and the significance of the coloured labels. The evaluation step took place after each workshop. The researchers met with managers and presented the workshop outcomes, and the managers were asked to give their assessment of both the workshop and its outcomes.

THREE ACTION CASES

Company A

Company A is owned by a large international enterprise group and manufactures customized heavy-duty screening equipment for industries worldwide.

Phase 1. Establishing the Focus Area: The Administrative Process

Interviews revealed that, although the company had several IT systems in daily use, some employees used them very little. The use of intelligence from the systems as a support for decision-making was very limited. They did however describe some communication problems between departments that were hard to identify precisely: "this thing with communication between different departments, that's really important and we have begun, but I think there's a lot more to do in order to cooperate well, and understand each other…to speak the same language…there are still many misunderstandings"

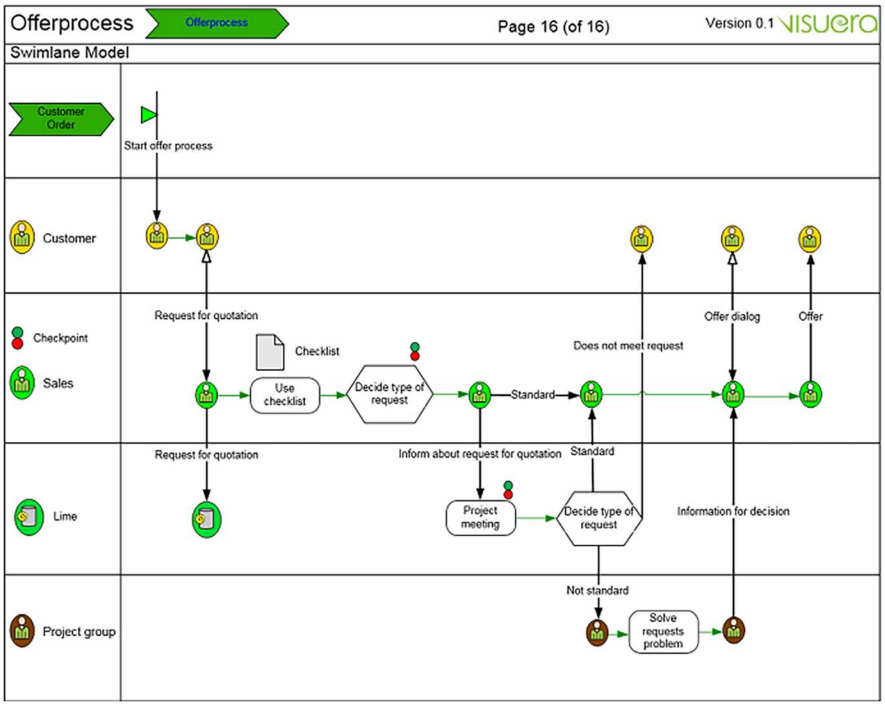
(employee, company A). Management representatives explained that there was something wrong in the administrative process; however they weren't sure how IT or BI&A could provide the necessary support. The symptom presented itself as confusion between product construction and the sales personnel, and also between sales, product designers and production workers. The production workers would weld parts according to a design that had wasn't up-to-date; sales information about specific details of the design was absent - halting the production process; procurement was late or parts missing from inventory because of lack of information. This discussion spilled over into the pre-workshop. The managers expressed the need for a coherent administrative process - a whiteboard was used to create a simple model. After few minutes the participants were familiar with the modelling approach and the head of IT drove the modelling and questioning. At the end of the session, the administrative process had been renamed the customer process, which initiated with a customer contact and ended when the final production order had been delivered to the production manager. This initial workshop was deemed a success: "we have tried to do this before, but we always gave up…this is a huge step forward."

Phase 2. Improving the Administrative Process with Process Modelling

The researchers created a digital version of the whiteboard using a process modelling tool provided by Visuera[2] for the pre-workshop. A central communication hub was identified: the morning meeting. Here sale representatives presented upcoming projects, customer information and change requests. The meeting then approved machines for production so that the sales reps could make formal offers to their customers. Sometimes the meeting was bypassed if the seller thought the workload was too high, or the machines were fairly standard. The sales manager kept the meetings short, and smaller groups met afterwards to resolve potential issues. The pre-workshop agreed that the model was an accurate enough representation of the current situation, and that the main workshop should focus on making an improved design for the future. The participants included the CEO, production manager, engineers and sales manager, nine people in total.

The revised process was split into two sub-processes: offer process and production order preparation and planning. Figure 4 shows part of the new offer process. The left column presents the involved roles in the process (top to bottom; customer, checkpoint, sales, Lime (sales IT support) and project group. The customer initiates the contact and starts the process. The sales department then follows new documented guidelines for which projects should be brought to the morning meeting (project meeting). Standardized machines with minor adjustments could be handled by the sales reps without the approval of the meeting. More heavily customized machines should be agreed at the meeting on the basis of an updated version of the offer document. Three control points are added (two depicted in Figure 4 as two small circles representing traffic lights) to ensure all relevant information was in place and to confirm that offers are identical to production orders. The final outcome of the process is a detailed purchase order from the customer delivered to the production manager and to the head of procurement (as an internal order). Only then would the product be planned and parts procured. The morning meeting also got a facelift, moving to another location and changing name to project meeting with a more detailed agenda and purpose. The model captured essential components needed to improve the process. It demonstrates activities (oval circles), activity flow (arrows pointing to the right) dataflow (arrows pointing up, down or both), relevant documents and decision points (hexagons). The second part of the new design was production order preparation and planning. In this process, sales continued to have an important role as a support to procurement, and in informing the customer about delivery date. The process specified internal activities and documents, including the technical contract review (where sales and procurement analysed what needed to be procured), and the administrative contract review (where the responsible sales rep handed over the contract to an assistant). The process had three main outcomes; the signing of the order confirmation, initiating the purchase process (procurement), and initiating the production process.

Figure 4. Excerpt from the new offer process



After the workshop, the new processes were presented to the whole sales function at a larger meeting. The processes were approved with minor changes and came into operation on January 1st of the following year. The Visuera process models were made available to serve as the foundation for development work which included information requirements analysis and development of key performance indicators. For instance: the production manager designed a metric for how often production needed to contact sales and design for supplementary information after the initiation of the production process. This metric decreased almost to zero after a month of working with the re-designed process. The indicator, although simple, spawned an interest in internal metrics for analytics, and in using IT to track them. Company A moved from the pre-aspirational maturity stage to position itself firmly as aspirational.

Company B

Company B is a family-owned company that manufactures in-car accessories for mobile devices that are sold both in Europe and in the US.

Phase 1. Establishing the Focus Area: Data Management for Inventory

After the initial interviews, the researchers presented management representatives with some of the findings from the empirical material. Using BI&A (or IT in general) outside production planning and standard economic analysis was a low priority. However, interviewees expressed frustration about missing or erroneous data, blaming it on bad input into the company systems. The managers admitted that they didn't know much about production cycle times or machine workload, and they had limited data for production planning. Production employees explained that they sometimes lacked plastic components for assembly because production information was unreliable. Sales personnel described problems in inventory control. Workers machining plastic components sometimes consulted the

company webpages to supplement poor design data. However, for the managers and owners, these information defects were not high priority. The most important factors for them were speed and agility. As soon as a new mobile device was released or a new car model presented, they would be the first company with an in-car solution. In addition, they had one customer serving the US market that accounted for half of all sales and therefore had priority over other customers. If a large US order came in it would jump the production queue, requiring all production to be rescheduled. In order to accommodate these issues, the company significantly overproduced plastic components to make sure they had enough inventory for assembly. The managers understood that this strategy was not sustainable, and it did nothing to address the problems identified by employees. The targeted focus area – data management for inventory – emerged from the meeting.

Phase 2. Information Requirement Analysis to Address the Inventory Management Problem

For the pre-workshop, a simple information requirements approach was devised. This time the coloured sticky labels were used to represent stakeholder roles (sales manager, assembler, logistics …) and data requirements. The simplicity of the approach evoked some negative body language at first from the CEO - however the production manager became immediately engaged and hesitation disappeared as he drove the analysis. The workshop was declared a success and the green light was given for the main workshop with both formal and informal leaders, and representatives from all departments.

The main workshop was initiated by the production manager, with the same simple analysis approach (Figure 5). It soon became clear the repercussions of poor inventory data management were more widespread than anyone had understood, affecting most of the stakeholder roles represented (including sales personnel, assembly line, packaging, production planning and component manufacture). The CEO was rather shocked: "I knew the numbers were not totally correct, but seeing how this affects the whole organization is a real eye-opener." The proficiency of many functions in the small company was undermined by data management problems. Difficulties were compounded by prioritizing US orders. It was fairly common for customers to alter their requirements, and for the affected functions to revise production, but the arrival of a US orders became a key decision point for many managers and workers. Production should be halted, a new production plan made, different components made, machines re-targeted, the assembly line reorganized, and assembly and shipment prioritized differently. Poor data management affected the analytical foundation for most of these decisions.

Researchers and company representatives met some days later to evaluate the outcome of the workshop. Managers expressed both satisfaction and surprise. They implemented metrics to understand the scale of disruption - the results are presented in Table 3.

Table 3 records the number of disruptions measured within the company over three months. The first column shows how many times the employees noted that there was an error regarding the number of products actually stored in inventory compared to the storage system data. The second column demonstrates how many times the production managers needed to change the production plans because of incoming priority orders (US), or because of inventory errors. The final column shows how many times the company needed to alter production because of design updates.

On the basis of this data, the production manager made changes to the planning process to help avoid unnecessary disruptions. The costs of poor inventory data management and its consequences for decision making and efficiency were apparent. Both CEO and production manager expressed the need to incorporate BI into their business – a clear signal of that the company was reaching the aspirational stage of BI maturity.

Company C

Company C produces bookshelves and is a subcontractor to a large Swedish furniture company.

Figure 5. Whiteboard and simple information analysis – white stickers for stakeholder roles, darker stickers for data requirements

Phase 1. Establishing the Focus Area: Decision-making for Production

Interviews revealed that the company was already using BI&A to some extent, for example by real-time monitoring of production output and quantifying truck deliveries. Initial discussions with managers therefore revolved around using existing data and analytics to better support decision-making. Workshops should identify which decisions were made, which were critical or problematic, and how BI&A could support them. More detailed focus emerged later.

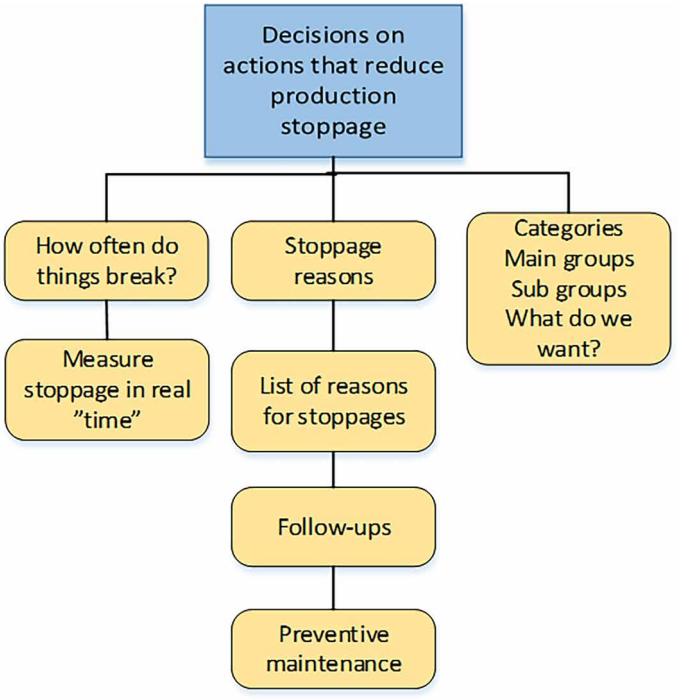
Phase 2. Decision Analysis for Production Line Stoppages

For the pre-workshop with management representatives the sticky coloured note system was adapted to decision analysis - specifically a very informal variant of decision tree analysis. White notes represent stakeholder roles, blue notes decisions, yellow notes data required to make the decision. Again, the simple approach was met with scepticism ("oh, are we back in kindergarten?" -owner-manager) quickly replaced by excitement ("this is all great stuff" -owner-manager). Managers for various functions where present, but the decisions put forward for analysis were mainly production

Table 3. Production disruptions, Company B

Date	Inventory error	Change of production plan	Change of product design
December	80	100	25
January	92	64	18
February	111	38	20

Figure 6. Stoppage action decision – data needed



orientated: for example decisions about reducing machine set-up time and machine improvement. Sufficient progress was made, and managers contacted 12 attendees for the main workshop.

The main workshop evolved a specific focus that seemed to concern most of the participants: what actions should be taken to reduce stoppage time in the company's five production lines. As with most SMME's, frequent stoppages affect the efficiency of many of the company's functions. Key data indicators were identified, for example stop causes and stop length, stop frequency for each of the lines etc. Figure 6 shows a digital version of the plastic wall where the dark grey box represents a decision and the light grey boxes the information needed.

A stoppage cause analysis is complex ("when looking at one side (of a bookshelf) we might notice there are some assembly holes missing - is that because the drill broke or because a screw got loose?") necessitating precise data.

The workshop evaluation meeting showed that managers were happy with both outcome and engagement levels. Most of the workshop issues were known, but it helped to develop a common understanding of the problem complexity. They chose an entrance point for tackling the problems – data management for production stoppage. This involved standardising the reporting of stops so that everyone would know which data to record, which IT system it should be stored in, and how to access it - so that, for instance, the production manager could have reliable data for their morning meeting. The team made a process model describing data paths around the machine operator. The managers provided a set of rules for clear data communication paths for operators, supervisors, production supervisors and production manager. They also specified three escalating categories of stoppages: quality issue, failure (halts the line) and security risk. All stoppages should be registered in the central production system, and each role was given specified data management procedures. At the time of writing the company was implementing stoppage metrics for use in morning meetings.

DISCUSSION

Company Results

Managers from all three companies expressed satisfaction with the interventions and made plans to continue working with the issues raised. Company A planned to implement further metrics to support analysis of their revised administrative processes and showed interest in using the modelling approach in other areas of the company. Business intelligence would help them develop a better understanding of their customers and markets, and identify quality issues. Company B called the intervention "a real eye opener," as they identified an inventory management problem with company-wide implications. They realized they needed to improve data quality to provide a foundation for future BI developments. Company C reported that the intervention had helped them to understand the scope of many issues around production stoppages and how to address the most serious problems. At the point of writing they were working on how they could expand their existing BI to analyse stoppages and develop their IT to support the new communication paths. The three companies identified a significant challenge in their core functions (primarily orders and production). They investigated key aspects of the function itself, the data needed to manage it, and the decisions required to address the challenge. They took steps to solve their problems, and showed clear signs of improved motivation to develop their BI and analytics capabilities.

Research Results

In terms of the Lavalle (2010) maturity model, maturity model, all the SMME's showed clear aspirational stage symptoms. They used analytics to justify actions (or nor at all), and focused chiefly on operations and production (not surprising for manufacturing companies) and cost efficiency. They exhibited lack of understanding of how to leverage analytics for business value, and the owner managers were sceptical - especially about IT investments. Their ability to capture, aggregate, analyse or share information was limited, and decision-making was informal. We sometimes used the term 'pre-aspirational' for these symptoms, because aspirational denotes a conscious desire to improve which was initially absent in two of the companies. Several conversations with key actors indicated that the transformed stage of the maturity model would never be appropriate for them, as it might be for larger companies. They simply did not have the resource or skills base to enable it, and their culture was much closer to the workshop floor than the boardroom. Nor did the rhetoric of moving through maturity stages appeal – they preferred tackling known problems in a sequential fashion. However, some adoption of BI&A will clearly be necessary to compete in the world of industry 4.0, and researchers should contribute with knowledge-based, tested approaches. The maturity model used in this work did not provide guidance for action; however, it was reasonably simple and effective to adapt the major categories of the model to the more action-oriented approach given in the research model (Figure 2). This model is rather general and could be instantiated in many different ways, for instance with different modelling and analysis techniques than those chosen for these cases. However, our instantiation proved reasonably effective - the elicitation approach (Sandkuhl et al. 2014) is well-known and simple to understand, and challenge analysis effective at identifying problems to tackle. For SMME's the workshop focuses on functional proficiency, data management and decision-making was also effective. Different informal modelling approaches were devised as starting points for the workshops: process modelling focuses directly on the function/operation, information requirements analysis on data management, and decision trees on decision-making. However, all the workshops included some elements of all three key elements: function, data, and decisions. Success seems more dependent on the immediacy of the approach (workshop actors should take it and run with it), than the choice of technique or its correct application. The workshops also helped participants to appreciate the business value of working with BI&A, something that has been highlighted as an obstacle (Vidgen, Shaw, & Grant, 2017). Key elements of the intervention are these: a real problem, low cost low effort, simple analysis techniques (focused on function, data, decisions), immediate results. The research confirms the work of Olszak and Ziemba (2012); lack of managerial support, and ignorance of how

BI&A could contribute to business success are barriers to BI&A adoption. The intervention approach helped address these barriers through a focus on management involvement and commitment, clear ownership of both problem and task, and the participative team approach of the workshops (critical success factors according to Hawking & Sellitto (2010), readiness components according to Anjariny & Zeki (2014). Our studies were noticeably less IT-oriented and project-oriented than some of the literature we studied, possibly because the SMME's are more focused on production technologies than information technology, and seldom employ matrix or project-based organisational structures. The study was not methodologically well-organised for hypothesis testing, but it comes as no great surprise that low cost initiatives with quick wins increase adoption motivation – this is a frequent assumption in both technology adoption and change management literatures.

Practice Recommendations

Based on the research findings, we offer some recommendations for practitioners in aspirational SMME's wishing to kick-start their BI&A journey and improve motivation:

- Identify a significant, but focused challenge with a core function/operation
- Establish clear ownership of the improvement process, and involve the important actors
- Choose an appropriate analysis strategy – for example, process, data or decision analysis
- Use a simple modelling technique with a small learning curve and don't insist on modelling technique correctness
- Model the existing operation - note problems and defects
- Identify simple metrics for the operation and make certain that base IT systems support them.
- Identify and implement improvements – use the metrics to follow up the changes
- Celebrate improvements and quick wins.

CONCLUSION

This research set out to devise and evaluate ways of improving BI&A motivation in SMME's. We used an action case research method to design a theory-based intervention approach, and tested it out in three small Swedish companies. There was some variation in the workshop techniques used. The research model turned out to be useful for structuring the working approach with the companies and supported the action case method. The low cost, quick win intervention strategy was reasonably effective, and the companies reported satisfaction with it. BI&A benefits, contributing to motivation improvements were easily observable. The research contributes with an account of how to provide action-oriented research models from descriptive BI&A theory for SMME's, where little research has previously been conducted. In particular the contribution focuses on early stage companies with poor motivation for adopting BI&A, and shows how to improve their level of engagement. It is limited by the focus on a small number of companies in a particular cultural context, and by problems with the methodological approach to hypothesis testing. In future work we plan to address motivational deficit in a range of SME's in other sectors, and to provide a more developed process-oriented approach to BI&A implementation. Moreover, a future step will be to combine the accumulated experience with these companies and previous research into a framework supporting SME's with their BI&A adoption journeys.

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REFERENCES

Airaksinen, A., Luomaranta, H., Alajääskö, P., & Roodhuijzen, A. (2015). Statistics on small and medium-sized enterprises. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Statistics_on_small_and_medium-sized_enterprises

Anderson-lehman, R., Watson, H. J., & Wixom, B. H. (2008). CHAPTER 57 Flying High with Real-Time Business Intelligence Continental's History. In *Handbook on Decision Support Systems* (Vol. 2, pp. 443–462). Springer-Verlag Berlin Heidelberg. doi:10.1007/978-3-540-48716-6_21

Anjariny, A. H., & Zeki, A. M. (2014). The important dimensions for assessing organizations' readiness toward business intelligence systems from the perspective of Malaysian organization. In *Proceedings - 2013 International Conference on Advanced Computer Science Applications and Technologies, ACSAT 2013* (pp. 544-548). doi:10.1109/ACSAT.2013.113

Baransel, A. E., & Baransel, C. (2012). Architecturing business intelligence for SMEs. In *Proceedings - International Computer Software and Applications Conference* (pp. 470-475). doi:10.1109/COMPSAC.2012.82

Cates, J. E., Gill, S. S., & Zeituny, N. (2005). The Ladder of Business Intelligence (LOBI): A framework for enterprise IT planning and architecture. *International Journal of Business Information Systems*, *1*(1/2), 220. doi:10.1504/IJBIS.2005.007408

Chen, H., Chiang, R. H., & Storey, V. C. (2012). Business Intelligence and Analytics: From Big Data To Big Impact. *Management Information Systems Quarterly*, *36*(4), 1165–1188. doi:10.2307/41703503

Chuah, M.-H., & Wong, K.-L. (2011). A review of business intelligence and its maturity models. *African Journal of Business Management*, *5*(9), 3424–3428. doi:10.5897/AJBM10.1564

Davenport, T. H., & Harris, H. G. (2007). *Competing on analytics: the new science of winning*. Boston: Harvard Business School Publishing Corporation.

Davison, R. M., Martinsons, M. G., & Kock, N. (2004). Information Systems Journal : Principles of Canonical Action Research. *Information Systems Journal*, *14*(1), 65–86. Retrieved from http://www.m-w.com. doi:10.1111/j.1365-2575.2004.00162.x

Eder, F., & Koch, S. (2018). Critical Success Factors for the Implementation of Business Intelligence Systems. *International Journal of Business Intelligence Research*, *9*(2), 27–46. doi:10.4018/IJBIR.2018070102

Grabova, O., Darmont, J., Chauchat, J.-H., & Zolotaryova, I. (2010). Business Intelligence for Small and Middle-Sized Entreprises. *SIGMOD Record*, *39*(2), 39–50. doi:10.1145/1893173.1893180

Gudfinnsson, K., & Strand, M. (2017). Challenges with BI adoption in SMEs. In *2017 8th International Conference on Information, Intelligence, Systems & Applications (IISA)* (pp. 1–6). doi:10.1109/IISA.2017.8316407

Gudfinnsson, K., Strand, M., & Berndtsson, M. (2015). Analyzing Business Intelligence Maturity. *Journal of Decision Systems*, *24*(1), 37–54. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/12460125.2015.994287 doi:10.1080/12460125.2015.994287

Hawking, P., & Sellitto, C. (2010). Business Intelligence (BI) Critical Success Factors. In *ACIS 2010 Proceedings*.

Krippendorff, K. (2004). Reliability in Content Analysis. *Human Communication Research*, *30*(3), 411–433. doi:10.1111/j.1468-2958.2004.tb00738.x

Kumar, P., Chauhan, D. S., & Sehgal, V. K. (2012). Selection of evolutionary approach based hybrid data mining algorithms for decision support systems and business intelligence. In *Proceedings of the International Conference on Advances in Computing, Communications and Informatics - ICACCI '12*. doi:10.1007/978-81-322-0740-5

Lahrmann, G., Marx, F., Winter, R., & Wortmann, F. (2011). Business Intelligence Maturity Models : An Overview. *44th Hawaii International Conference on System Sciences* (pp. 1–12). doi:10.1109/HICSS.2011.90

Laursen, G. H., & Thorlund, J. (2010). *Business analytics for managers: Taking business intelligence beyond reporting*. New Jersey: John Wiley & Sons.

Lavalle, S., Hopkins, M. S., Lesser, E., Shockley, R., & Kruschwitz, N. (2010). Analytics : The New Path to Value. *MIT Sloan Management Review*. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Analytics+:+The+New+Path+to+Value#0

Llave, M. R. (2017). Business Intelligence and Analytics in Small and Medium-sized Enterprises: A Systematic Literature Review. *Procedia Computer Science*, *121*, 194–205. doi:10.1016/j.procs.2017.11.027

Olszak, C., & Ziemba, E. (2012). Critical success factors for implementing business intelligence systems in small and medium enterprises on the example of upper Silesia, Poland. *Interdisciplinary Journal of Information, Knowledge, and Management, 7*(September).

Papachristdoulou, E., Koutsaki, M., & Kirkos, E. (2017). Business intelligence and SMEs: Bridging the gap. *Journal of Intelligence Studies in Business*, *7*(1), 70–78. Retrieved from https://ojs.hh.se/index.php/JISIB/article/view/201

Popovič, A., Hackney, R., Coelho, P. S., & Jaklič, J. (2012). Towards business intelligence systems success: Effects of maturity and culture on analytical decision making. *Decision Support Systems*, *54*(1), 729–739. doi:10.1016/j.dss.2012.08.017

Rajterič, I. H. (2010). Overview of business intelligence maturity models. *Management: Journal of Contemporary Management*, *15*, 47–67. doi:10.1007/BF01530759

Rockart, J. F. (1979). Chief executives define their own data needs. *Harvard Business Review*, *57*(2), 81. PMID:10297607

Sandkuhl, K., Stirna, J., Persson, A., & Wißotzki, M. (2014). *Enterprise Modeling* (J. L. G. Diets, E. Proper, & J. Tribolet, Eds.). Berlin: Springer-Verlag Berlin Heidelberg; doi:10.1007/978-3-662-43725-4

Scholz, P., Schieder, C., Kurze, C., Gluchowski, P., & Böhringer, M. (2010). Benefits and Challenges of Business Intelligence Adoption in Small and Medium-Sized Enterprises. In *ECIS 2010 Proceedings* (pp. 1–12).

Sharda, R., Delen, D., & Turban, E. (2014). *Business Intelligence and Analytics: Systems for Decision Support (Global 10t)*. Essex: Pearson Education Limited.

Shrouf, F., Ordieres, J., & Miragliotta, G. (2014). Smart factories in Industry 4.0: A review of the concept and of energy management approached in production based on the Internet of Things paradigm. In *IEEE International Conference on Industrial Engineering and Engineering Management* (pp. 697-701). doi:10.1109/IEEM.2014.7058728

Spruit, M. Sacu, C. (2010). BIDM - The Business Intelligence Development Catalina Model. In *Proceedings of the 12th International Conference on Enterprise Information Systems*. Retrieved from https://www.researchgate.net/publication/220710949_BIDM_-_The_Business_Intelligence_Development_Model

Tan, C.-S., Sim, Y.-W., & Yeoh, W. (2012). A Maturity Model of Enterprise Business Intelligence. *Communications of the IBIMA*, *18*(1), 3–19. doi:10.1675/1524-4695(2008)31

Thamir, A., & Theodoulidis, B. (2013). Business Intelligence Maturity Models: Information Management Perspective. *Information and Software Technologies, 403*, 198–221. doi:10.1007/978-3-642-41947-8_18

Trieu, V.-H. (2016). Getting value from Business Intelligence systems: A review and research agenda. *Decision Support Systems*, *93*, 111–124. doi:10.1016/j.dss.2016.09.019

Valacich, J., & Schneider, C. (2010). *Information Systems Today - Managing in the digital world* (4th ed.). New Jersey: Pearson Education.

Vidgen, R., & Braa, K. (1997). Balancing interpretation and intervention in information systems research: the action case approach. In *Information Systems and Qualitative Research* (pp. 524-541). doi:10.1007/978-0-387-35309-8_26

Vidgen, R., Shaw, S., & Grant, D. B. (2017). Management challenges in creating value from business analytics. *European Journal of Operational Research*, *261*(2), 626–639. doi:10.1016/j.ejor.2017.02.023

Voicu, V., Zirra, D., & Ciocirlan, D. (2010). Business Intelligence Effective Solutions of Management. *Business (Atlanta, Ga.)*, 181–185.

Williams, S., & Williams, N. (2007). *The Profit Impact of Business Intelligence*. Amsterdam: Morgan Kaufmann.

Yeoh, W., & Koronios, A. (2010). Critical success factors for business intelligence systems. *Journal of Computer Information Systems*, *50*(3), 23–32. Retrieved from http://hdl.handle.net/10536/DRO/DU:30033043

ENDNOTES

1 MMC2: Measuring and Managing Continuous Improvements in Medium-Sized Manufacturing Companies
2 http://visuera.com/verktyg/visuera-modeler.aspx

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